Electromechanical Batteries

New materials, new design concepts prompt re-examination of an old idea

At LLNL we have an ongoing program to develop modular electromechanical batteries (EMBs) based on new materials and novel design concepts. We visualize using 1-kW·h modules for electric and hybrid-electric automobiles (larger modules for buses and locomotives) and 2- to 25-kW·h modules for stationary applications, such as power conditioning, load shifting, and distributed storage.

Novel design concepts, new materials, high performance

As its name suggests, an EMB is the mechanical equivalent of an electrochemical storage battery; it is based on the flywheel concept of energy storage. Our EMB consists of a high-speed fiber-composite rotor supported by a magnetic bearing system integrated with a special ironless generator/motor, all housed in a sealed, evacuated enclosure. Electrical energy is coupled into and out of the module inductively, through a re-entrant vacuum barrier. These "systems-oriented" design concepts—plus using the latest super-strong carbon fibers in the rotor and high-field permanent magnet material in the generator/motor and in the magnetic bearings—are essential to achieving the EMB's predicted high-performance levels.

APPLICATIONS

- *Electric and hybrid-electric cars, buses, trucks, and locomotives*
- *Uninterruptible power supplies (UPS) for computers*
- *Load-leveling for electric utilities or their customers*
- *Pulse power supplies for specialty applications*

The performance characteristics of the EMB modules we are developing include very high specific power (10 or more kW/kg, 100 times that of typical batteries), and high-energy recovery efficiencies (kW·h out vs kW·h in), up to 95% compared to a typical 60% to 70% for electrochemical cells. In addition, we believe our EMBs should have a very long and maintenance-free service lifetime (10 years or more), even with virtually unlimited numbers of deep-discharge cycles. These characteristics set the EMB apart from any other known electrochemical cell.

Magnetic bearings, a key technology

LLNL's prototype electromechanical battery.

Because the EMB rotor turns in vacuo at high speeds, the best way to support it against gravity, minimize frictional drag, and achieve long service life is to use a magnetic suspension/bearing system. To that end, we have developed new concepts for magnetic bearings that promise to be simpler and less expensive than the servo-controlled bearings now in use. Our bearings are of the "passive" type, employing permanent magnets to supply the levitating forces and rotordynamic effects to achieve stability.

Progress to date

To date, we have tested all EMB components (such as bearings, generator, and vacuum in a sealed-off chamber) and have built some operable modules.

One module, designed to store about 1 kW·h, has delivered over 100 kW with measured recovery efficiencies in excess of 90%.

Availability: Our EMB technology is available now. The Laboratory is seeking collaborators to work on commercializing the electromechanical battery for a wide variety of possible applications.

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